THE PETROLOGY OF THE ROUEN MOUNTAINS, NORTHERN ALEXANDER ISLAND

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ABSTRACT. A large batholith of probable Tertiary age, which exceeds 1 000 km^2 in area and comprises tonalite, granodiorite, adamellite, granite and quartz-feldspar-porphyry, intrudes (?) Permian–Triassic sediments of the LeMay Formation. Thirty-one modal analyses are included in a field and petrographical description of this batholith; enclaves of both sedimentary and igneous origin are described and possible source material for the latter is discussed. Minor basic and intermediate dykes are the youngest rocks in the range. Geophysical evidence for a possible cogenetic relationship between the extrusive and intrusive rocks, which form a north–south belt through central Alexander Island, is discussed. In a regional setting, the igneous rocks of Alexander Island are comparable to those of the South Shetland Islands in occupying a position to the west of a Mesozoic batholith which underlies the west coast of the Antarctic Peninsula.

THE first distant sighting of the mountains of northern Alexander Island was made by T. von Bellingshausen in 1821; but it was not until the Deuxième Expédition Antarctique Française of 1908–10 led by Dr J.-B. Charcot, when the coast was approached to within 3 km, that the mountains were mapped in any detail. The three north-easternmost peaks were collectively termed "Massif Paris" and Charcot believed these were separated by a deep depression from the more extensive "Massif Rouen" to the south. In 1948, C. C. Brown, of the Falkland Islands Dependencies Survey, mapped the eastern side of the mountains from the ground and confirmed the appearance of a gap between the two "massifs". However, a later study of air photographs taken during the Ronne Antarctic Research Expedition (1946–48) revealed this was a minor feature and subsequently the name Rouen Mountains came to be accepted for the whole range with Mount Paris confined to the most prominent peak in the north (Fig. 2).

Numerous observations of the mountains were made from the air by subsequent expeditions to the Marguerite Bay area: British Graham Land Expedition (1934–37), United States Antarctic Service Expedition (1939–41), United States Navy Operation Highjump (1946–47) and Ronne Antarctic Research Expedition (1946–48); following these Searle (1961) published a map of Alexander Island at a scale of 1 : 200 000. Despite this, however, no geological information had been obtained, although Adie (1964) suggested that the greater part of northern Alexander Island was composed of "basement" schists, and King (1964), from aerial observations, believed that "basement" gneisses cropped out in the northern Rouen Mountains.

Reconnaissance geological mapping in northern Alexander Island commenced in 1970–71, when C. M. Bell accompanied a geophysical investigation team into the area and briefly visited several localities, including four in the Rouen Mountains (Bell, 1974). Subsequently, in the austral summer of 1975–76 the author mapped the mountains in detail as part of a two-season programme concentrating on the geology of northern Alexander Island.

PHYSIOGRAPHY

The Rouen Mountains, centred on lat. 69°13′S, long. 70°50′W, form the most northerly and extensive occurrence of igneous rocks in a broad north–south-trending belt through central Alexander Island, which includes the Elgar Uplands, Colbert Mountains, Walton Mountains and Staccato Peaks (Fig. 1).

The mountain range (Fig. 2), with peaks to 3 000 m occupies an area of approximately 1 500 km^2, extends 65 km from Mount Bayonne in the north to Mount Cupola in the south-east, and 45 km from east to west at the latitude of its eastern extension, Mount Calais, and includes the isolated Care Heights in the extreme south-west. With the exception of

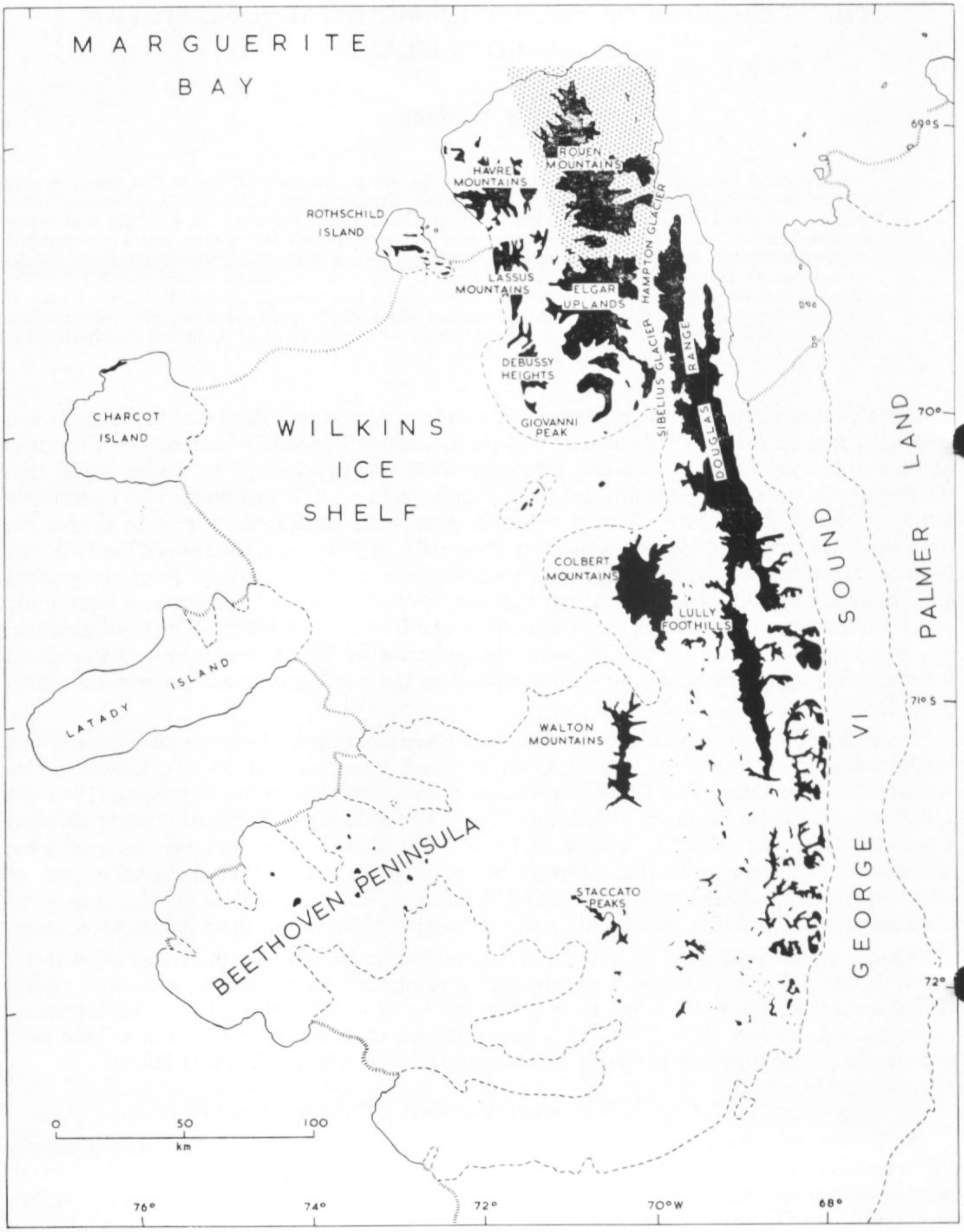
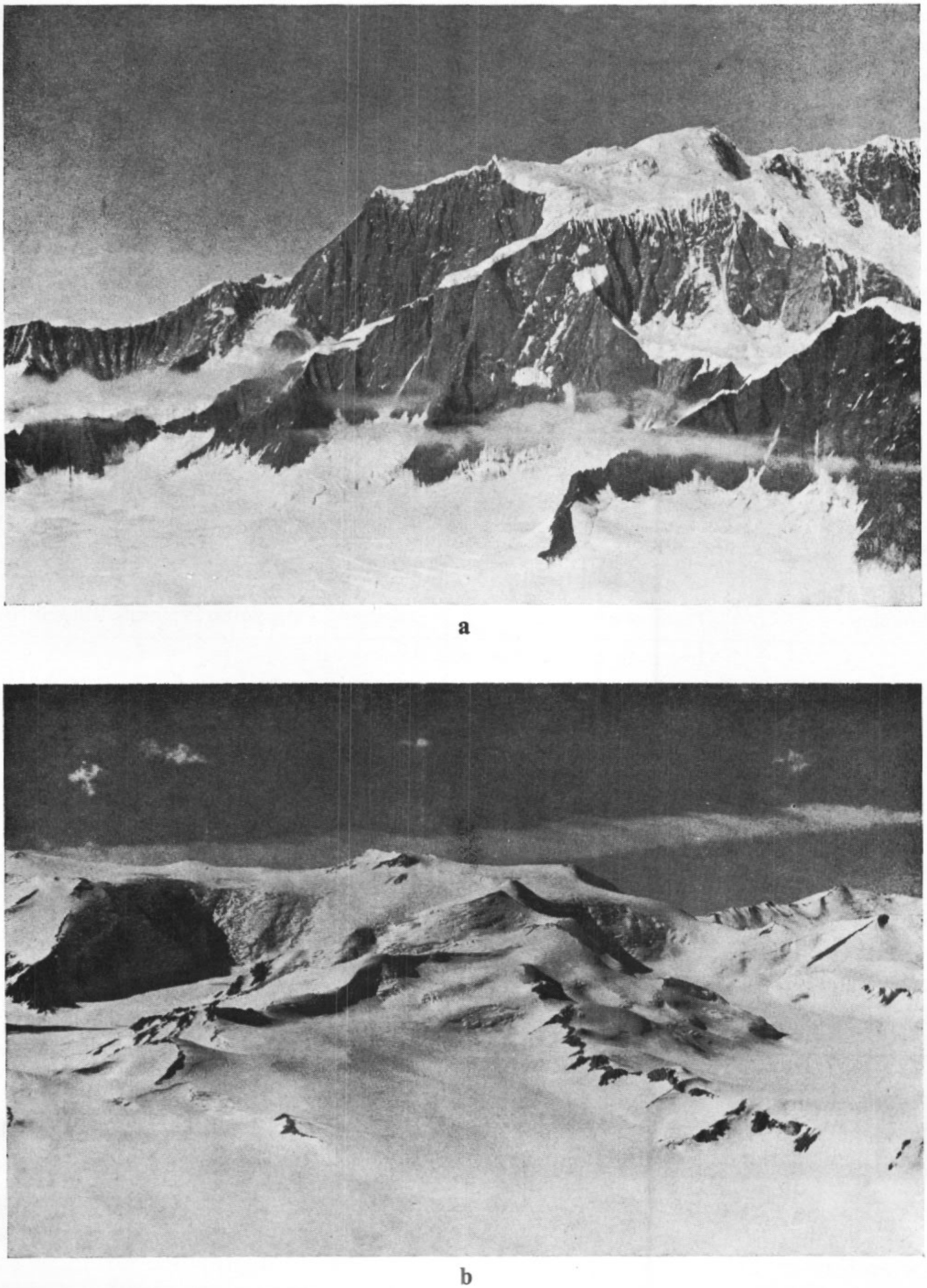


Fig. 1. Sketch map of Alexander Island showing the location of the Rouen Mountains (Fig. 2) and areas referred to in the text.



a

b

Fig. 3. Contrasting aerial views of the Rouen Mountains:

a. The precipitous northern ridges of Mount Calais rising vertically from the Roberts Ice Piedmont (600 m a.s.l.).

b. The gentler relief in the south-west Rouen Mountains where ridges descend from the relatively flat summit plateau in the background to the snowfield at a height of 1 000 m a.s.l.

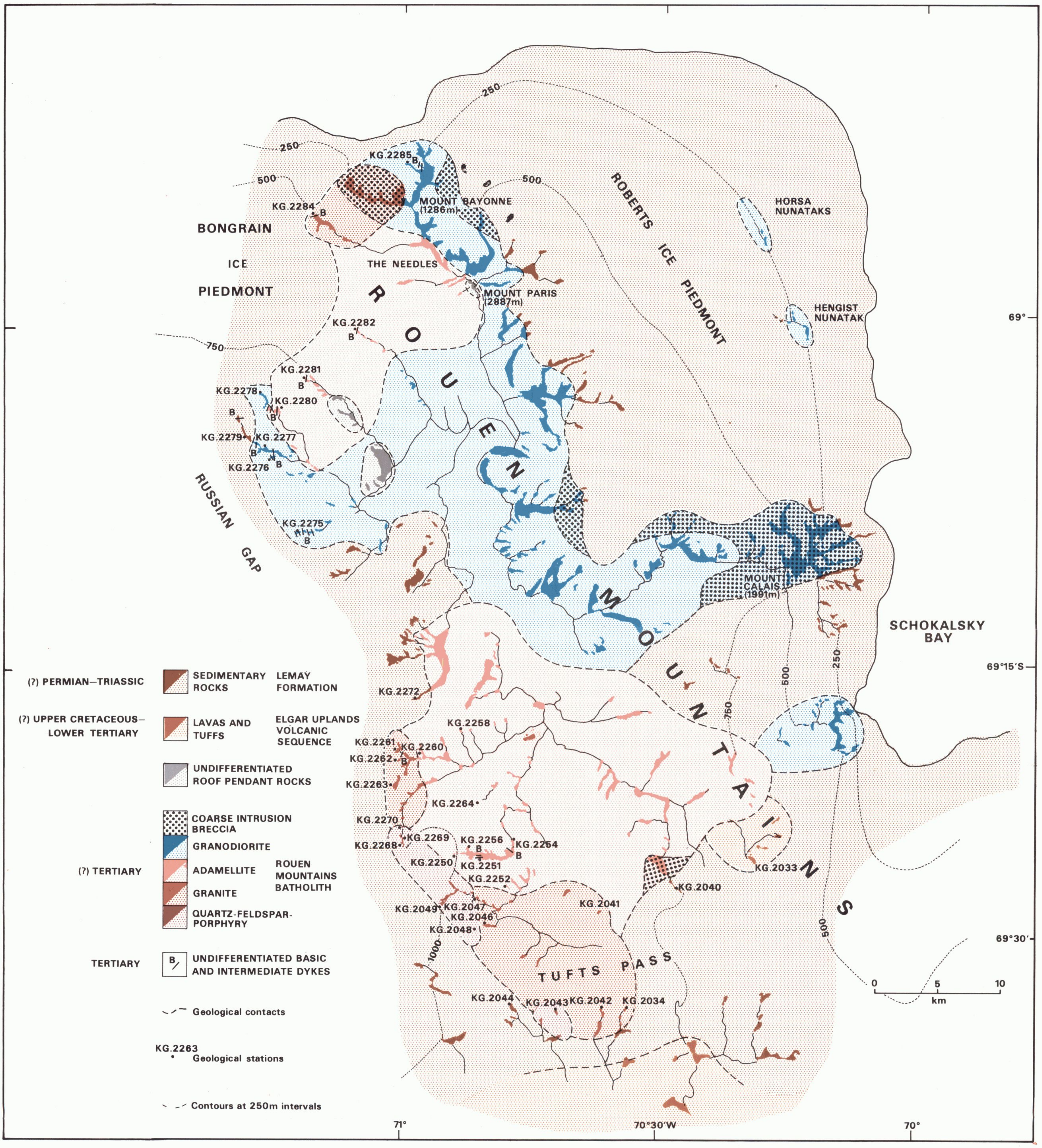
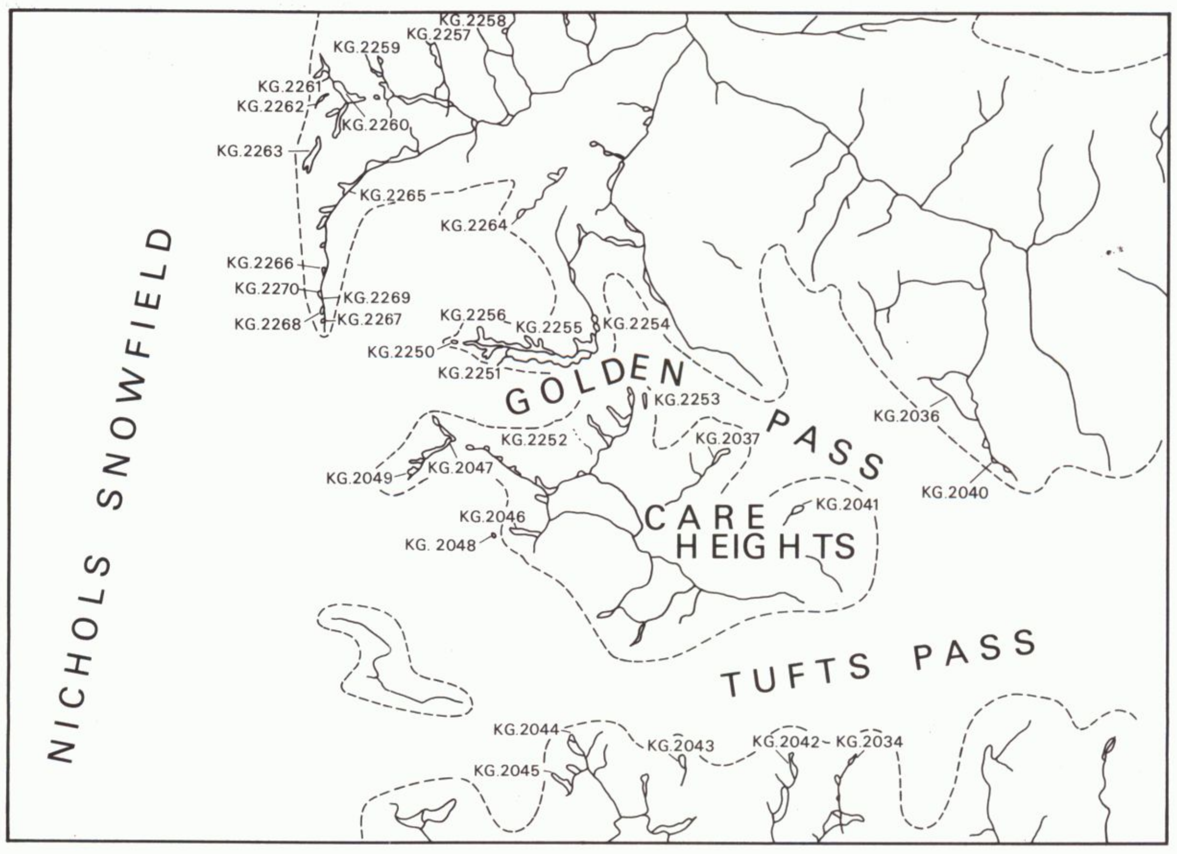


Fig. 2. Geological sketch map of the Rouen Mountains, northern Alexander Island.



the southern boundary, where the batholith described in this paper extends across a narrow snow gap named Tufts Pass, the igneous rocks crop out solely within the mountainous area bounded by Nichols Snowfield, Russian Gap and Bongrain Ice Piedmont to the west, Marguerite Bay to the north and Roberts Ice Piedmont and Schokalsky Bay to the east.

The sinuous snow-covered summit plateau is relatively flat and attains its highest point in the vicinity of Mount Paris but glacial erosion has deeply incised the margins to produce short precipitous ridges and pinnacles (Fig. 3a), especially in the north and east, where the spectacular "Needles" occur on the ridge to the south of Mount Bayonne. Erosion is less marked in the west, where the Havre Mountains have restricted the movement of ice in Russian Gap and kept the snow level generally higher (Fig. 3b).

This paper is based on field work carried out in the north-west, west and south Rouen Mountains and Care Heights, where the exposure is good and access is relatively easy. Additional information was obtained from flights over the north-east of the range where, although exposure is good, access from the ground is severely limited.

GENERAL STRATIGRAPHY

The stratigraphy of northern Alexander Island is summarized in Table I. The oldest rocks are deformed mudstones, arkoses and lithic arenites, which locally reach the chlorite zone of the greenschist facies of regional metamorphism. They crop out in the Douglas Range, marginal areas of the Rouen Mountains and Elgar Uplands, and in the mountains to the west: the Havre Mountains, Lassus Mountains, Debussy Heights and Giovanni Peak (Fig. 1). A tuffaceous horizon from similar rocks in the Lully Foothills of central Alexander Island has yielded a benthonic invertebrate fauna of Middle–Upper Triassic age (Edwards, 1982). The overall name LeMay Formation (Edwards, 1982) has been proposed for these rocks and their equivalent sequences in the northern and southern parts of the island.

TABLE I. SEQUENCE OF GEOLOGICAL EVENTS IN NORTHERN ALEXANDER ISLAND

Age		
Cenozoic	Palagonite-breccias and olivine-basalts	Beethoven Peninsula volcanic rocks
(? Tertiary)	Intermediate to basic dykes Aplite and pegmatite dykes and veins Quartz-feldspar-porphyry Granite–adamellite Granodiorite	Rouen Mountains batholith
(?) Upper Cretaceous–Lower Tertiary	Basaltic and andesitic lavas, tuffs and agglomerates (Hornblende-porphyry dykes)	Volcanic sequence of Elgar Uplands
	UNCONFORMITY	
(?) Permian–Triassic	Mudstones, arkoses and lithic arenites locally affected by low-grade regional metamorphism	LeMay Formation

Agglomerates, tuffs and subordinate lavas forming the volcanic sequence of the Elgar Uplands crop out in the Elgar Uplands and in a low-lying area to the west of Sibelius Glacier, and rest on an eroded surface of these metasediments. A K-Ar age of 70 Ma has been obtained from a tuff in a similar formation in the Colbert Mountains of central Alexander Island

(Grikurov and others, 1967) and fossil angiosperm leaves found in the volcanic rocks of eastern Elgar Uplands, although poorly preserved, "... show some resemblance to those in the South Shetland Islands ..." where "... associated lavas have now been dated at about 60 Myr ..." (Thomson and Burn, 1977). Hornblende-porphyry dykes, widely reported from northern Alexander Island, cut deformed sediments in the Elgar Uplands and are thought to be feeders for the overlying volcanic sequence (Bell, 1974).

No contacts are exposed between the major intrusive phase (the Rouen Mountains batholith) and the extrusive volcanic sequence of the Elgar Uplands, and the field relations set only a broad age limit on the batholith as being younger than the (?) Permian–Triassic LeMay Formation. Indirect evidence, the absence of hornblende-porphyry dykes from the batholith and the possible intrusion of bedded lavas and tuffs by late-stage acid dykes in an inaccessible exposure to the south-east of Mount Cupola (KG.2033), however, suggests that the plutonic rocks are either contemporaneous with or younger than the Elgar Uplands volcanic sequence.

Thin basic to intermediate dykes cut all the major formations and the youngest rocks are isolated outcrops of palagonite-tuffs and olivine-basalts found in the Elgar Uplands (personal communication from R. W. Burn) and on Rothschild Island (paper in preparation by B. W. Care). These compare closely with the Cenozoic volcanic rocks described from Beethoven Peninsula of south-western Alexander Island (Bell, 1973*a*), which form part of a broad belt of Cenozoic volcanic activity extending across western Antarctica from the Ross Sea through Marie Byrd Land and Ellsworth Land into the northern Antarctic Peninsula and appear to range from Oligocene (26–29 Ma) to Quaternary (0.2 Ma) (LeMasurier and Rex, 1982).

These comparisons give possible age limits to the batholith of 30–60 Ma.

ROUEN MOUNTAINS BATHOLITH

The Rouen Mountains contain the largest single occurrence of plutonic rock on Alexander Island and are dominated by an extensive almost homogeneous batholith of granodiorite, which intrudes folded sediments of the LeMay Formation. Smaller, possibly zoned, plutons of adamellite and granite were intruded into the north and south-west of the mountains, and this episode of plutonic activity ended with the intrusion of aplite and pegmatite dykes and small bodies of quartz-feldspar-porphyry. The existence of a compositional break within the rocks of the Rouen Mountains batholith, as shown by the ternary diagram (Fig. 4), suggests that the more acid members are part of a later discrete phase rather than products of a continuous fractionation process, although fractionation has probably occurred within each phase. Signs of forcible emplacement are seen in the extensive intrusion breccias but no evidence of granitization is visible, as the margins of the intrusions are sharp and contact metamorphic effects are restricted to the albite-epidote-hornfels facies.

Smaller occurrences of plutonic rock in Alexander Island include diorite and tonalite at Staccato Peaks and nearby nunataks in the south of the island (Bell, 1973*b*), adamellite at Giovanni Peak in the north (Bell, 1974), granodiorite and gabbro in the Walton Mountains (personal communication from C. W. Edwards), and granodiorite at Rothschild Island (paper in preparation by B. W. Care).

Similar rocks found throughout the Antarctic Peninsula are regarded as a direct continuation of the calc-alkaline intrusive suite of the South American Andes and have been collectively termed the Andean Intrusive Suite (Adie, 1955) but range in age from Upper Jurassic to Lower Tertiary (Rex, 1976).

In Palmer Land, the rock types encompass: diorite to granodiorite in the Lassiter and Black Coasts to the south (Singleton, 1980; Rowley and Williams, 1982), an approximately concentrically zoned pluton of diorite with an adamellitic core in the Clifford Glacier area of the northern Black Coast (Anckorn, 1981), and granodiorite through granite to quartz-plagioclase-porphyry in the north-west adjacent to George VI Sound (Skinner, 1973).

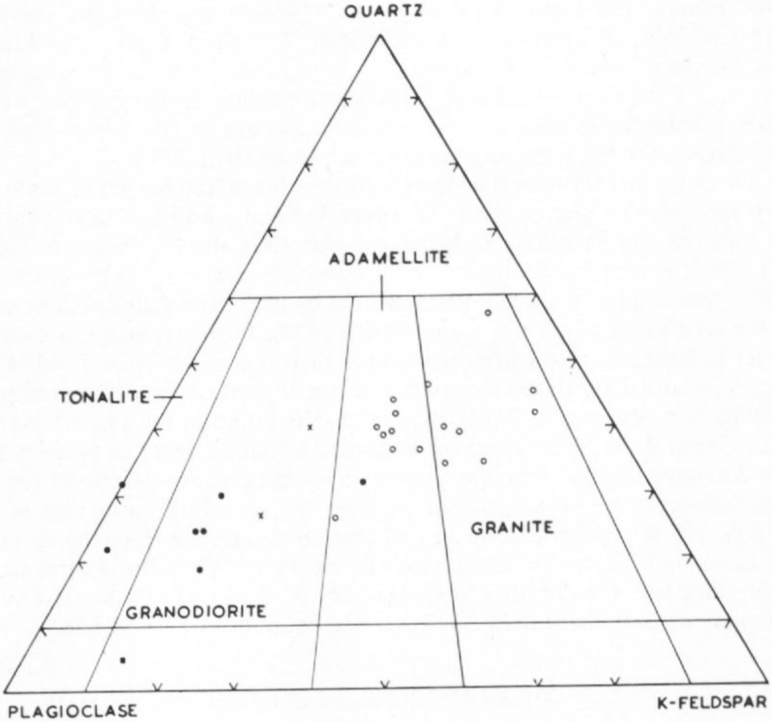


Fig. 4. Ternary diagram showing the modal composition of rocks from the Rouen Mountains batholith (after Nockolds, 1954).

A possible cogenetic origin for the main igneous rocks on Alexander Island is indicated by the results of recent aeromagnetic surveys over the Antarctic Peninsula. Renner and others (1982) have shown that Alexander Island is relatively quiet magnetically with the exception of two secondary features. One of these is a linear belt of positive magnetic anomalies of up to 200 gammas amplitude running approximately along long. 70°W (Fig. 5) and which in southern Alexander Island ". . . . appears to be associated with local outcrops of dioritic intrusive rock within (?) Carboniferous sediments of the Staccato Peaks and Walton Mountains . . .". This zone can be traced northward throughout the length of the island where it broadens to include the predominantly volcanic outcrops of the Colbert Mountains and the Elgar Uplands, and the Rouen Mountains batholith, and is still evident off the northern coast of Alexander Island (profile 1 in Fig. 5).

Further evidence for a cogenetic origin is provided by the composition of the volcanic rocks. These are predominantly basaltic and andesitic in the Elgar Uplands but become dacitic and rhyolitic towards the top of the succession in the southern Colbert Mountains (personal communication from R. W. Burn), and are thus effusive equivalents of the plutonic rocks occurring within the belt.

Granodiorite

Granodiorite of a uniform grey colour crops out on the long ridges in the north-west of the mountains and on a small mountain to the south of Mount Calais (personal communication from R. G. Barrett) (Fig. 2). In the north-east, the inaccessible Horsa Nunataks and Hengist Nunatak, and the extensive exposures of the Rouen Mountains to the west and south of Roberts Ice Piedmont, are of a similar grey-coloured rock, which forms coarse intrusion

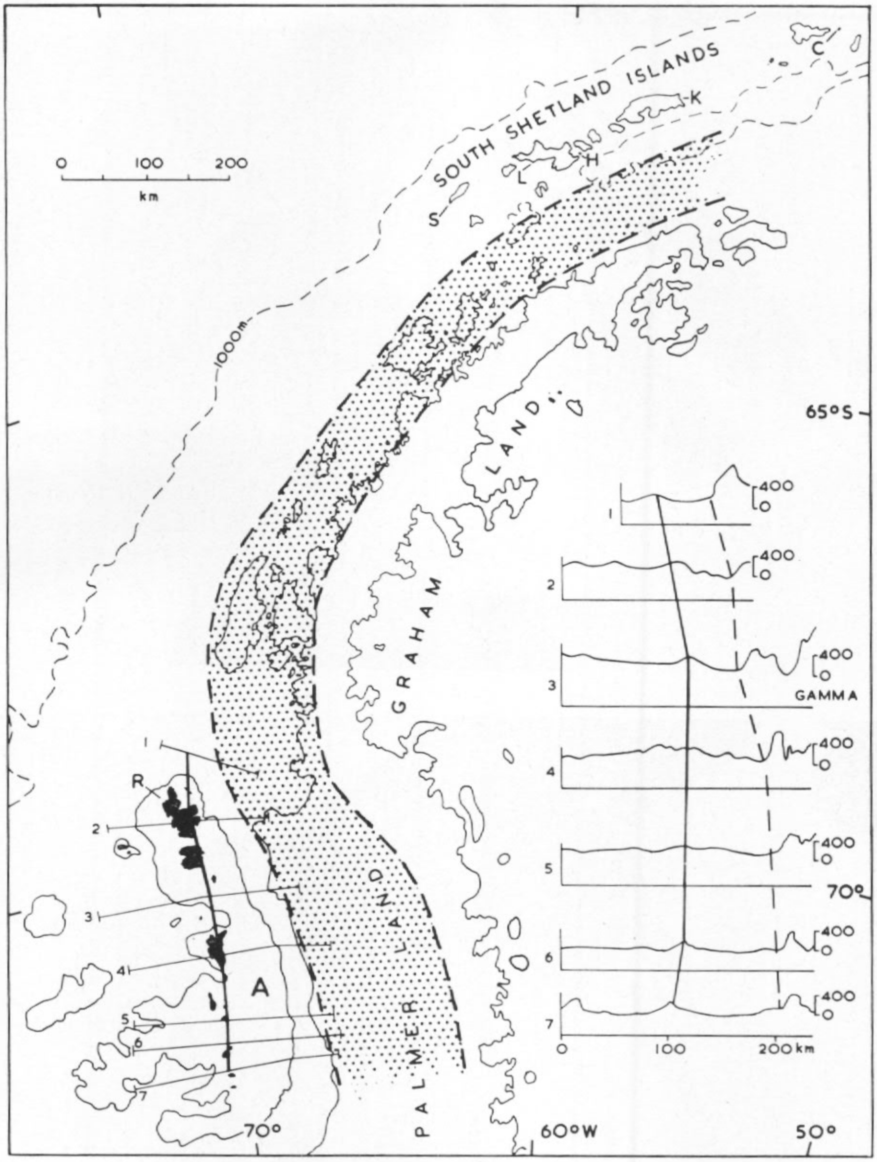
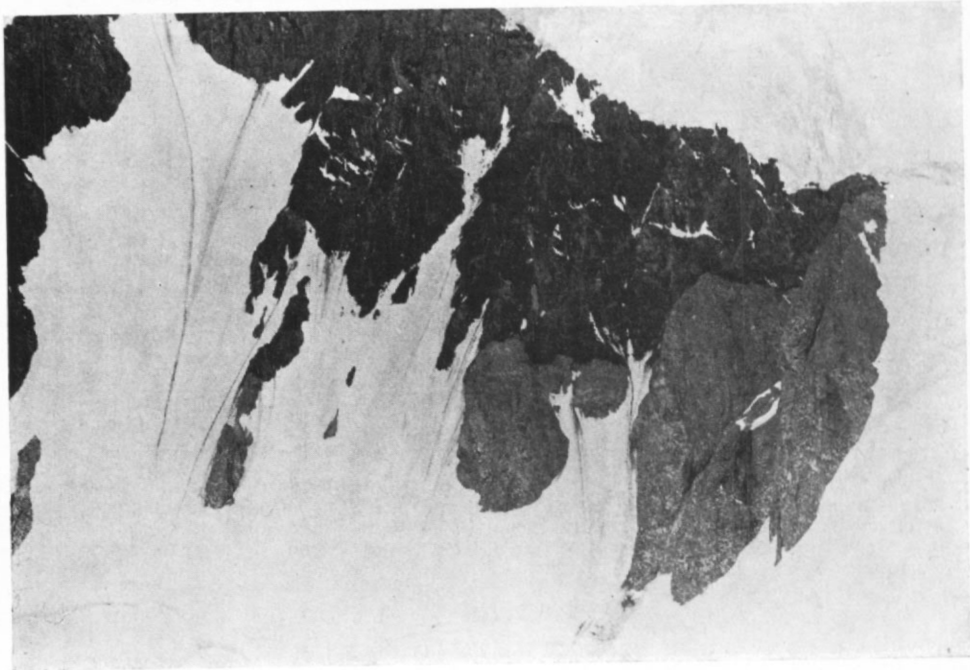


Fig. 5. Map of the Antarctic Peninsula showing the location of Alexander Island (A) and the South Shetland Islands relative to the proposed Andean batholith (stippled). The igneous rock outcrops (black) and aeromagnetic profiles across Alexander Island (from Renner and others, 1982) are also shown. (C Cornwallis Island; H Half Moon Island; K King George Island; L Livingston Island; R Rouen Mountains; S Smith Island.)

breccias with the deep brown sediments of the LeMay Formation (Fig. 6a).

The granodiorite is invariably xenolithic with fine-grained rounded inclusions of igneous material ranging from 2 mm across at station KG.2285 to, more commonly, 10 cm at station KG.2275. Adjacent to the contact with the LeMay Formation on the north-westernmost ridge of the Rouen Mountains, the xenoliths are of typically banded arenaceous and argillaceous

a



b

Fig. 6. a. Aerial view of a coarse intrusion breccia in the north-east Rouen Mountains with granodiorite invading dark metasediments of the LeMay Formation.
b. Telephoto view of xenolithic granite intruding the LeMay Formation south of Tufts Pass.

rock showing varying stages of assimilation. Basic to intermediate dykes are common within the granodiorite but aplite dykes were observed at only one locality (KG.2279).

In the hand specimen, the granodiorites are all medium to coarse-grained and equigranular. They differ from rocks of the granite–adamellite phase in having a higher colour index with the appearance of hornblende alongside biotite, absence of rounded quartz phenocrysts and a smaller amount of pink feldspar. This reduced and variable amount of potash feldspar extends the compositional range of the granodiorites into adamellites (KG.2275.21) and tonalites (KG.2278.1 and 2285.1) (Table II).

TABLE II. MODAL ANALYSES OF ROCKS FROM THE GRANODIORITE INTRUSIVE PHASE

	1	2	3	4	5	6	7
Quartz	27.0	20.3	24.5	14.9	14.1	26.7	3.3
Orthoclase	25.2	11.8	8.7	1.1	11.1	–	9.4
Perthite	1.8	–	0.6	–	–	–	–
Plagioclase	31.3	50.1	47.1	50.5	47.6	57.5	60.0
Hornblende	7.5	7.4	8.8	19.4	15.1	2.7	–
Biotite	5.5	9.3	6.1	11.8	10.9	11.5	–
Chlorite*	1.1	0.3	2.5	1.7	0.5	0.5	17.2
Iron ores	0.6	0.8	1.7	0.6	0.7	1.1	0.4
Other minerals	–	–	–	–	–	–	9.7†
Plagioclase composition	An_{15-25}	An_{30-36}	An_{32}	An_{28-42}	An_{31-43}	An_{15-26}	An_{13-27}

* After biotite and hornblende.
† Epidote and calcite after plagioclase.
Minimum of 1 000 points counted per section.

1. KG.2275.21 Adamellite; south-east margin of Russian Gap.
2. KG.2276.4 Granodiorite; north-west Rouen Mountains.
3. KG.2277.4 Granodiorite; north-west Rouen Mountains.
4. KG.2278.1 Tonalite; north-west Rouen Mountains.
5. KG.2279.1 Granodiorite; north-west Rouen Mountains.
6. KG.2285.1 Tonalite; near Cape Bayonne.
7. KG.2277.3 Altered granodiorite; north-west Rouen Mountains.

In thin section, the hypidiomorphic granular rocks comprise a coarse interlocking matrix of quartz, potash feldspar and plagioclase enclosing subhedral biotite and hornblende. The quartz is invariably fractured with undulose extinction and in specimen KG.2275.21 it forms aggregates up to 8 mm. Zoning is usually well developed in oligoclase/andesine (An_{15-43}) and sericitization of the cores of some zoned crystals and along twin planes is apparent. Untwinned orthoclase and rare perthite have a dusty appearance due to incipient alteration. Twinned plagioclase enclosed in potash feldspar in specimen KG.2275.21 has margins of untwinned albite (Fig. 7b), while myrmekite is developed in specimen KG.2279.1.

Subhedral to anhedral biotite ($\alpha =$ straw, $\beta = \gamma =$ dark brown) is present as flakes up to 2.5 mm and commonly forms glomeroporphyritic aggregates with hornblende reaching 9 mm in specimen KG.2278.1. This primary biotite is poikilitic to iron ore, apatite and zircon, and alteration to chlorite is widespread.

Subhedral primary hornblende ($\alpha =$ pale brown, $\beta =$ greenish, $\gamma =$ dark green,

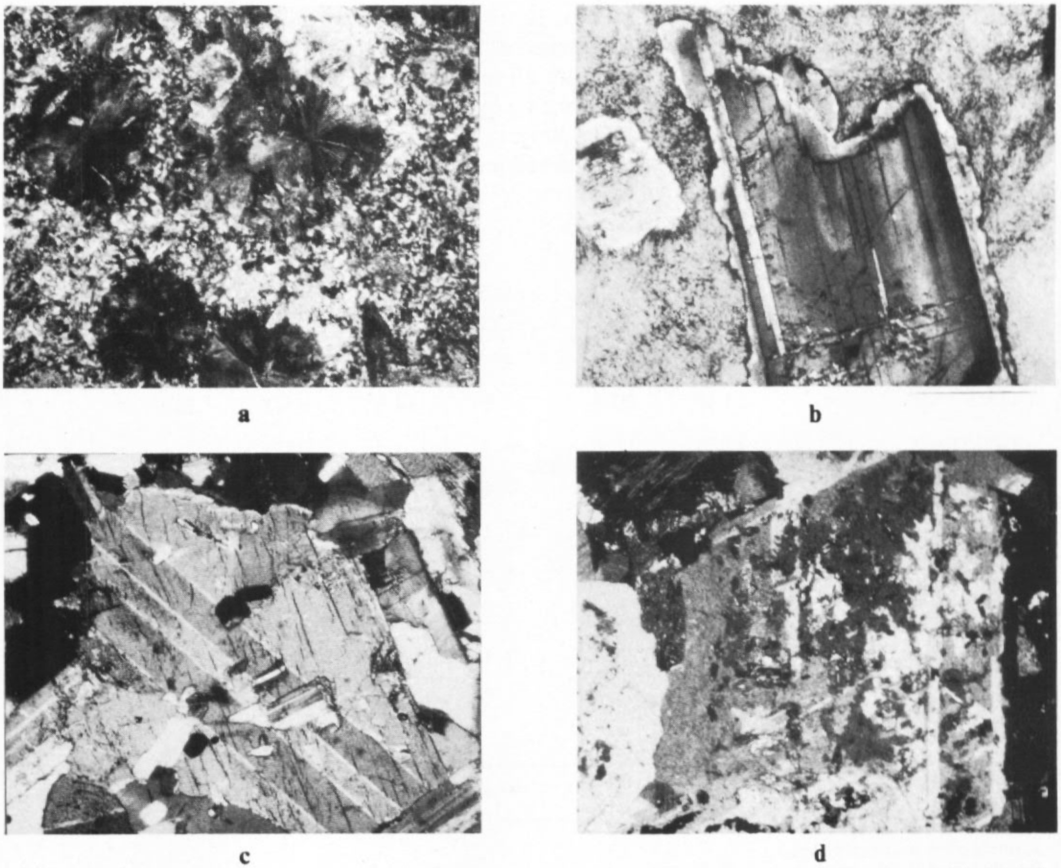


Fig. 7. a. Feldspathic micro-spherules within the matrix of a quartz-feldspar-porphyry; south of Tufts Pass (KG.2043.1, X-nicols; ×50).
b. Twinned plagioclase enclosed in potash feldspar of an adamellite and exhibiting a mantle of untwinned albite; south-east Russian Gap (KG.2265.21; X-nicols; ×200).
c. A tonalite showing twinned hornblende poikilitically enclosing plagioclase, quartz and iron ore; north-west Rouen Mountains (KG.2278.1; X-nicols; ×50).
d. Plagioclase crystal in granodiorite showing patchy alteration to albite (dark grey), calcite (pale grey) and small epidotes; north-west Rouen Mountains (KG.2277.3; X-nicols; ×50).

$\gamma : c = 13$–$27°$) forms individual laths up to 7 mm in specimen KG.2275.21 and frequently exhibits simple and multiple twinning (Fig. 7c). Some alteration to secondary biotite and chlorite is evident with associated epidote, iron ore and sphene. Other accessory and secondary minerals include small blood-red flakes of haematite and a pale brown to olive-green pleochroic (?) stilpnomelane associated with the chlorite in specimen KG.2275.21.

Thin-section examination of a conspicuous pink variety from within the granodiorite (KG.2277.3) reveals an extremely altered mineralogy with the plagioclase showing patchy alteration to albite and heavy saussuritization to large plates of calcite and small crystals of epidote (Fig. 7d). Hornblende and biotite are both highly chloritized with few relict fragments.

Granite–adamellite

Rocks of this phase cover extensive areas in the south-west and north-west Rouen Mountains and Care Heights (Fig. 2). In the north-west, a well-jointed, coarse-grained, pale grey

TABLE III. MODAL ANALYSES OF ROCKS FROM THE GRANITE–ADAMELLITE INTRUSIVE PHASE

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Quartz	32.6	40.9	43.2	57.4	38.5	32.6	24.5	42.1	36.9	33.2	44.4	38.4	37.5	46.3	39.1	40.0
Orthoclase	12.1	39.0	25.8	15.1	31.1	28.3	16.9	13.7	26.2	29.6	29.7	16.6	1.0	0.3	–	4.1
Perthite	32.6	8.9	17.5	18.9	8.4	0.3	11.9	14.0	6.9	9.5	2.4	1.6	28.4	22.9	27.9	31.6
Plagioclase	17.9	8.3	8.4	8.0	19.9	27.8	40.5	24.8	25.9	24.9	19.7	28.8	29.8	26.9	30.2	22.9
Biotite*	3.7	1.8	3.9	0.2	1.2	10.5	5.7	5.0	0.2	2.8	3.2	1.6	2.5	3.5	1.8	1.3
Iron ores	1.0	0.8	0.4	0.4	0.5	0.5	0.5	0.3	–	–	0.5	0.7	0.4	0.1	0.3	0.1
Myrmekite	0.1	–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–
Graphic granite	–	–	0.8	–	0.1	–	–	–	3.9	–	–	12.3	–	–	–	–
Other minerals	–	0.3	–	–	–	–	–	–	–	–	0.1	–	0.4	–	0.8	–
Plagioclase composition	An_{20}	An_{19-21}	An_{17-23}	An_{14}	Indet.	An_{12-24}	An_{26}	An_{25}	An_{28}	An_{17-23}	An_{20-24}	An_{27}	An_{8-10}	An_{12}	An_{10}	An_{24-26}

* Includes alteration to chlorite.
Minimum of 1 000 points counted per section.

1. KG.2034.1 Granite; south side of Tufts Pass.
2. KG.2034.2 Granite; south side of Tufts Pass.
3. KG.2042.1 Granite; south side of Tufts Pass.
4. KG.2046.1 Granite; west Care Heights.
5. KG.2048.2 Granite; west Care Heights.
6. KG.2250.2 Adamellite; north-west side of Golden Pass.
7. KG.2251.1 Adamellite; north-west side of Golden Pass.
8. KG.2256.1 Adamellite; south-west Rouen Mountains.
9. KG.2258.1 Adamellite; west Rouen Mountains.
10. KG.2260.1 Granite; west Rouen Mountains.
11. KG.2262.1 Granite; west Rouen Mountains.
12. KG.2264.1 Adamellite; south-west Rouen Mountains.
13. KG.2280.3 Adamellite; north-west Rouen Mountains.
14. KG.2281.4 Adamellite; north-west Rouen Mountains.
15. KG.2282.1 Adamellite; north-west Rouen Mountains.
16. KG.2284.1 Granite; north Rouen Mountains.

weathering adamellite crops out on three of the long north-west-trending ridges into Bongrain Ice Piedmont and also forms the series of spires known as the "Needles" on the ridge running north from Mount Paris. A single outcrop of massive coarse-grained granite crops out on a ridge to the west of Mount Paris and produces a coarse intrusion breccia with darker granodiorite on the faces to the south-west of Cape Bayonne. Pegmatite lenses occur only within the granite and both rock types are cut by near-vertical basic to intermediate dykes.

In the south-west, the rocks have a characteristic pale pink colour and vary from adamellite to granite (Table III) with the most coarse-grained member, the granite, forming two ill-

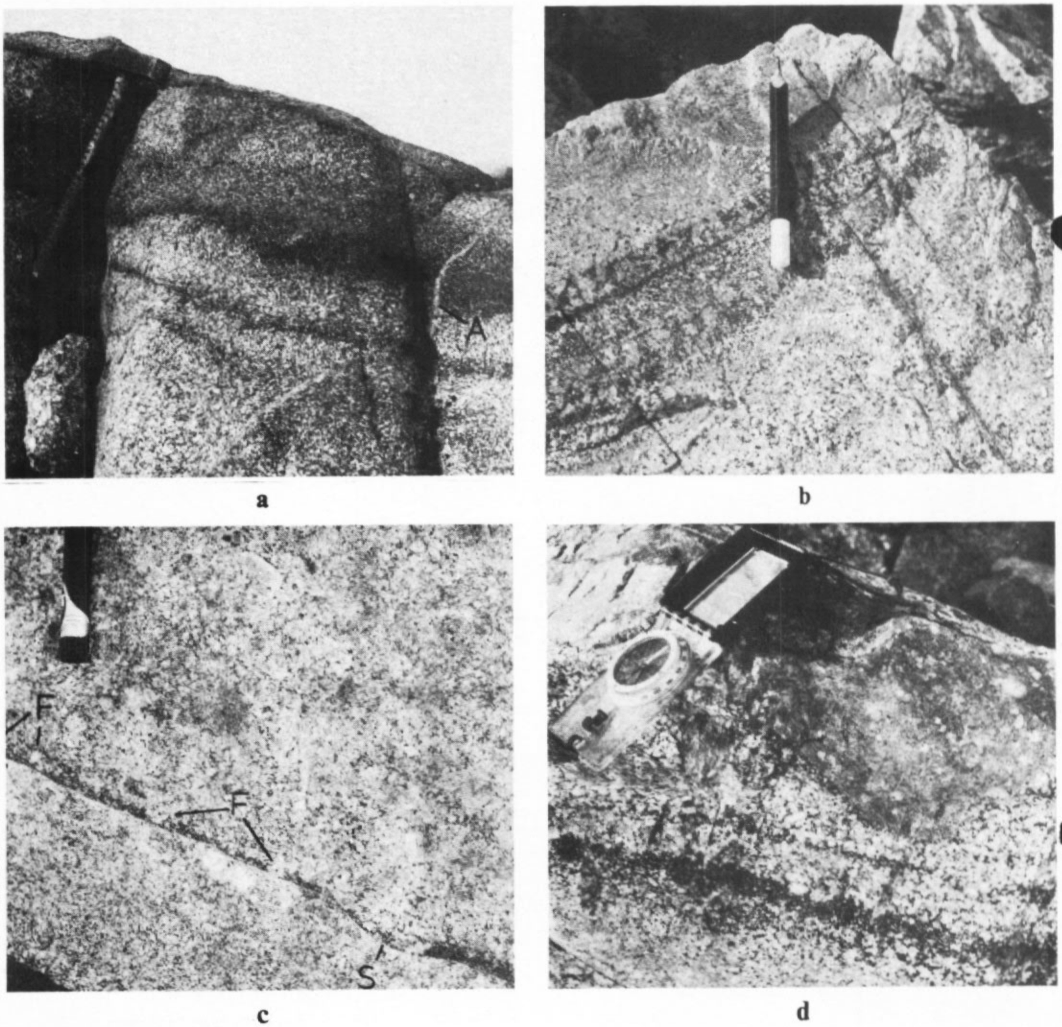


Fig. 8. Examples of cumulate layering within the granite of the south-western Rouen Mountains and Care Heights:
a. Rhythmic banding cut by a thin aplite vein (A) at station KG.2253. The hammer shaft is 35 cm long.
b. "Dendritic" layering at station KG.2263 caused by the growth of feldspars within the mafic bands. The pencil is 8 cm long.
c. Thin mafic layer at station KG.2250 disrupted by the growth of feldspars (F) and scouring action of magma (S). The pen is 14 cm long.
d. Mafic layer "bent" around a porphyritic xenolith at station KG.2263. The compass dial is 5 cm in diameter.

defined areas in the extreme south-west and in Care Heights. As in the north-west Rouen Mountains, no contacts between the two rock types were observed.

Granite intrudes dark-coloured sediments in several cliff faces bordering Tufts Pass (Fig. 6b) and at stations KG.2034 and 2042 it was seen to contain abundant xenoliths (up to 30 cm across) and larger irregular patches of a mesocratic igneous rock of granodioritic composition. These enclaves are rich in hornblende, quartz and feldspar phenocrysts, and are thought to be part of an earlier intrusive phase.

Aplite dykes and pegmatite segregations are ubiquitous within the granites and adamellites of the south-west Rouen Mountains but few basic to intermediate dykes were observed.

Cumulate layering is only found in the granite–adamellite member of the south-west Rouen Mountains and Care Heights, and occurs as both isolated patches up to 20 cm and, more commonly, continuous layers from 1 to 10 cm thick of fine-grained melanocratic granite containing over 75% biotite and opaque minerals. The layers exhibit sharp lower contacts frequently disrupted by randomly orientated feldspar phenocrysts and down-warped by xenoliths (Fig. 8d), while the upper margins grade into the granite and adamellite by a decrease in mafic mineral content to the average 3–5% of the host rock and an increase in grain-size. Rhythmic units comprising three or more of these layers are occasionally seen (Fig. 8a). Some layers show peculiar dendritic accumulations of the dark minerals extending from a well-defined basal layer (Fig. 8b) and this could be the result either of disturbances within the enclosing liquid during crystal accumulation or of later disruptive growth of feldspars within the mafic layers.

Thin concentrations of mafic minerals within the host granite parallel some of the aplite dykes and pegmatite veins, though this is thought to be due to coincidental intrusion of the acid material parallel to the banding, as other late-stage dykes cross-cut the igneous layering.

In the hand specimen, the true granites vary from porphyritic with rounded often fractured quartz up to 1 cm, pink feldspar up to 2 cm and smaller white plagioclase prisms in a coarse matrix of the same minerals to medium-grained and equigranular. Abundant small quartz crystals occur throughout the matrix of the adamellites which, although possessing a pinkish weathering surface, are internally a pale to mid grey colour with a peculiar orange tinge supplied by the plagioclases.

Biotite ($\alpha =$ straw, $\beta = \gamma =$ dark brown) is present in varying amounts, reaching 10% in the most mafic granite (KG.2250.2), as subhedral crystals and ragged masses up to 4 mm. Complete chloritization of the biotite accompanied by exsolved iron ore is seen in specimen KG.2264.1 and alteration has produced a colourless radiating (?) vermiculite in specimen KG.2258.1. In specimen KG.2282.1 a large biotite has recrystallized into smaller plates of biotite and chlorite.

Quartz is seen as rounded fractured crystals with an undulose extinction commonly forming aggregates up to 1.5 cm across. Numerous crystals poikilitically enclose feldspar, biotite and iron ore. In the adamellite at station KG.2281, the large quartz crystals are accompanied by abundant small quartz grains from 0.1 to 0.5 mm scattered throughout the phenocryst minerals and the matrix. Coarse granophyric intergrowths with perthite and orthoclase are common in specimens KG.2258.1 and 2264.1, and in specimen KG.2282.1 large (1 mm) embayed quartz blebs are embedded in perthite. Poorly developed, lobate myrmekitic patches of quartz-riddled plagioclase were seen at several potash feldspar/plagioclase contacts in specimens KG.2048.2 and 2250.2.

Anhedral to subhedral plagioclase as single prisms and aggregates reaching 2 cm across are widespread throughout both the granite and adamellite members of the batholith. In the south-west Rouen Mountains and Care Heights, oligoclase (An_{14-28}) with normal and oscillatory zoning is common, while in comparison similar rocks from the north-west Rouen Mountains show only poorly developed zoning of the plagioclases and these have a more sodic composition (An_{8-12}). Sericitization affects many of the cores and marginal zones of crystals and is also common in the plagioclase components of patch perthite. Some saussuritization has occurred with the formation of calcite and epidote (KG.2254.1).

Potash feldspars reach 1.5 cm in specimen KG.2252.1 and they are represented by Carlsbad-twinned orthoclase and anhedral perthite, of which the braid, flame and patch varieties are common. Perthite is the predominant potash feldspar within the adamellite of the north-west Rouen Mountains and all the potash feldspars contain minute inclusions giving them a dusty appearance. Rare crystals of antiperthite were seen in specimen KG.2034.1 and in the hand specimen KG.2264.1 several large pink feldspars are surrounded by a border of plagioclase.

Accessory minerals include iron ore as small euhedral crystals up to 0.8 mm (KG.2282.1) and larger skeletal masses, sphene as ragged crystals (often as inclusions in the opaque minerals), apatite and zircon. A ragged (1.2 mm), pale pink poikilitic garnet occurs in specimen KG.2280.3 and muscovite forms interstitial laths up to 2 mm in length in specimen KG.2282.1. The common secondary minerals are iron ore, chlorite, calcite and epidote.

Quartz-feldspar-porphyry

Leucocratic, fine-grained igneous rocks, containing conspicuous phenocrysts of quartz and feldspar and smaller mafic minerals crop out in the south-west Rouen Mountains and in west Care Heights, and they also form small exposures on the south side of Tufts Pass in the northern Elgar Uplands (Fig. 2). These rocks are often highly foliated and suffer deep weathering, which leaves the quartz standing proud and the feldspars with a deep orange surface coloration. At station KG.2048 the contact with the well-jointed granite has weathered to a gully; elsewhere the contact is obscured by snow gaps or scree ridges.

Irregular intrusions of porphyry rock cut dark finely banded metasediments on two low ridges in the area and xenoliths of the country rock are incorporated within the porphyry with apparently little alteration. At station KG.2268 the porphyry in contact with the metasediments displays a chilled margin in which the rock has a yellowish very fine-grained matrix but it still contains phenocrysts of quartz and feldspar. These phenocrysts only reach 3 mm compared to 1 cm in the unaltered part of the intrusion.

In thin section, phenocrysts of quartz, plagioclase and potash feldspar, together with smaller crystals of biotite, muscovite and iron ore are surrounded by a dusty, pale brown cryptocrystalline matrix. Textures are uniform but the proportions of phenocryst minerals and the nature of the feldspars vary greatly (Table IV). Typically, oligoclase (An_{7-24}) dominates as subhedral crystals or glomeroporphyritic aggregates up to 5 mm across. Heavy alteration to pale brown saussurite and sericite is widespread and oscillatory zoning was seen in one plagioclase from specimen KG.2049.8.

Specimen KG.2041.4, collected from an isolated foliated outcrop adjacent to coarse-grained granite, is peculiar among the porphyries in that it possesses a high percentage (14.7%) of potash feldspar (microcline and perthite) compared to 0–8.6% in the other rocks. This gives the rock a composition more closely allied to the granite and it might be a chilled marginal variety of granite rather than a separate intrusion. Elsewhere, the subhedral potash feldspars are perthites and Carlsbad-twinned orthoclases, affected by only slight alteration along fractures.

Clear, rounded and occasionally fractured quartz phenocrysts possess deeply embayed faces and rare inclusions of biotite and groundmass material, and they occur as single crystals or aggregates up to 1 cm across (KG.2049.4). Biotite and muscovite are present as rare bent flakes, invariably showing alteration to chlorite and fine-grained opaque material along cleavage planes. Iron ore is seen in all sections as a fine peppering and less commonly as anhedral crystals and aggregates reaching 2 mm.

The matrix, which in the hand specimen varies from pale grey to deep purple in colour, is composed essentially of microcrystalline phenocryst minerals and abundant feldspathic

TABLE IV. MODAL ANALYSES OF QUARTZ-FELDSPAR-PORPHYRY ROCKS

	1	2	3	4	5	6	7	8
Quartz	9.8	3.1	16.1	5.4	8.8	10.7	13.7	5.7
Potash feldspar	14.7	0.2	8.6	1.8	0.7	0.2	–	3.1
Plagioclase	9.6	2.7	8.6	16.0	12.8	8.6	10.0	6.6
Biotite*	–	–	–	1.5	2.3	–	2.0	0.2
Muscovite*	0.3	–	0.5	–	–	0.1	–	–
Iron ores	0.1	0.2	–	0.4	0.7	0.5	1.0	–
Groundmass	65.5	93.8	66.2	74.9	74.7	79.9	73.3	84.4
Plagioclase composition	An_7	An_8	An_{20-24}	An_{16-24}	An_{20}	An_{8-12}	An_7	An_7

* Includes chlorite alteration.
Minimum of 1 000 points counted per section.

1. KG.2041.4 East Care Heights.
2. KG.2043.1 South side of Tufts Pass.
3. KG.2048.1 West Care Heights.
4. KG.2049.4 West Care Heights.
5. KG.2049.8 West Care Heights.
6. KG.2268.1 South-west Rouen Mountains.
7. KG.2269.1 South-west Rouen Mountains.
8. KG.2270.1 South-west Rouen Mountains.

micro-spherules (Fig. 7a). The latter reach 0.5 mm in diameter in specimen KG.2043.1 and occasionally form radiating rims to quartz phenocrysts. In specimen KG.2048.1 the micro-spherulitic texture is absent but small myrmekite crystals comprise over 50% of the matrix. Accessories include small apatite, sphene and epidote grains, a broken crystal of deep brown pleochroic zoned (?) lamprobolite in specimen KG.2049.8 and calcite as large interstitial plates.

MINOR INTRUSIONS

Aplite dykes

Sharply defined intrusions of aplite cut the granite and adamellite of the south-west Rouen Mountains and Care Heights but they are seldom seen within other igneous rocks of the batholith. Aplite dykes also cut the granodioritic xenoliths at station KG.2042 and schistose metasediments at station KG.2047. Two intrusive types were recognized: an early pinkish weathering set of fine to medium grain-size containing small mafic minerals and commonly exceeding 15 cm in width and a later, very fine-grained cross-cutting set which rarely reach 3 cm in width and weather to a pale grey colour. The wider dykes are frequently associated with areas of orange staining and are in part joint-controlled, whereas the latter set are often very contorted.

In thin section, the dykes are characterized by a saccharoidal texture. Quartz, orthoclase (showing pale brown alteration) and microperthite are common in the coarse aplites (average grain-size 0.5–1.0 mm) with plagioclase, biotite (generally altered to chlorite) and iron ore as rare secondary minerals. In contrast, the finer-grained aplites (average grain-size 0.02 mm) are composed solely of quartz and orthoclase, and where they cut the earlier dykes contain xenocrysts and xenoliths of the coarser aplitic material (KG.2263.3).

Pegmatite veins

Pegmatite concentrations, commonly seen as lenses, thin discontinuous veins and marginal pockets within aplite dykes, are confined to the granite and adamellite members of the batholith. At station KG.2251, a 4 cm wide vein has a centre of coarse white feldspar with margins of smaller pink feldspar crystals. The vein bifurcates and is in part bordered by a concentration of mafic minerals within the host adamellite.

Basic to intermediate dykes

Dykes of microgabbro, microdiorite and andesite are found within all the major intrusive rocks of the Rouen Mountains except the quartz-feldspar-porphyry. They also cut the metasediments of the LeMay Formation on the ridges which trend north-west into the Bongrain Ice Piedmont. The intrusions are steeply dipping, frequently porphyritic and range in width from 0.5 to 5 m (Fig. 9). Chilled margins are common, some showing alignment of small feldspar phenocrysts, and slight shearing of the plutonic rocks adjacent to the contacts is observed. Xenoliths of both mesocratic igneous rock with hornblende needles and fine-grained metasediments are present within the dykes.

In the field, two intrusive types were recognized: a medium-grained, pale grey-green porphyritic variety with phenocrysts of white feldspar and dark mafic minerals giving a distinct spotted appearance to the rock, and a mid to dark green, medium- to fine-grained variety, occasionally porphyritic and often possessing a typical red-brown weathering crust. Although both intrusive varieties occur together in several localities, no age relationships were seen but

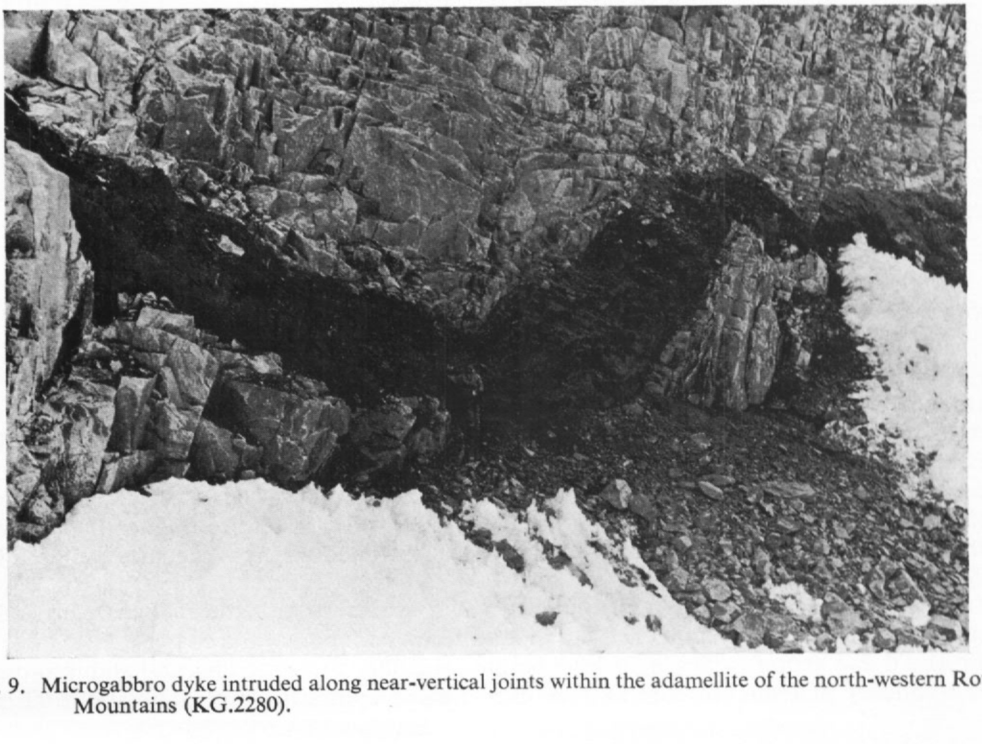


Fig. 9. Microgabbro dyke intruded along near-vertical joints within the adamellite of the north-western Rouen Mountains (KG.2280).

at station KG.2275 a 5 m wide dyke of the non-porphyritic variety is cut by several 2 cm thick veins of finer-grained material trending parallel to the dyke walls.

In thin section, the rocks show a varied mineralogy with much hydrothemal alteration. Plagioclase and ferromagnesian minerals are common phenocrysts within a groundmass of either the same mineralogy or of a deep brown-green cryptocrystalline mat of alteration minerals. Pale green to neutral subhedral augite ($\gamma : c = 50°$) with concentric zoning and an "hour-glass" extinction is a common phenocryst mineral reaching 2 mm in specimen KG.2275.11. Smaller anhedral crystals of augite occur in the groundmass and in specimens KG.2275.4 and 2276.7 it is pale purple-brown titanaugite. Marginal alteration to chlorite is often seen and the pyroxenes enclose iron ore.

Plagioclase having a wide compositional range (An_{15-63}) is present as phenocrysts up to 2.5 mm but it is more commonly seen as crystals of indistinct form in the groundmass. Sericitization is widespread and some of the phenocrysts show alteration to calcite and epidote.

Amphibole is absent from the majority of the dykes but in specimen KG.2261.2 subhedral crystals of hornblende with a pleochroism scheme α = yellow-green, β = yellow, γ = brown and $\gamma : c = 17°$ are the only mafic minerals present. In specimen KG.2277.1, hornblende phenocrysts, showing patchy or complete alteration to chlorite, occur with plagioclase; hornblende in the matrix is unaltered.

Biotite (α = straw, $\beta = \gamma$ = dark brown) was recognized in only one dyke rock (KG.2276.7) as rare subhedral groundmass laths with plagioclase and chlorite. Pseudomorphs after ferromagnesian minerals (possibly (?) olivine, (?) pyroxene and (?) amphibole) by chlorite, calcite, epidote and iron ore are common. Accessories are iron ore, sphene, minute apatite needles and occasional interstitial quartz. Other alteration minerals include prehnite and a deep brown, microcrystalline clay mineral ((?) smectite).

Some of the dykes contain amygdales, which in specimen KG.2275.4 reach 3 mm in diameter and are composed of interlocking aggregates of zeolites ((?) natrolite and (?) mesolite) with occasional irregular patches of epidote.

VOLCANIC SEQUENCE OF THE ELGAR UPLANDS

Rocks of this sequence crop out on two ridges approximately 10 km to the south-east of Mount Cupola (Fig. 2). At least five massive, sub-horizontal brown-grey lava flows alternate with beds of greenish scree, presumably the weathering products of tuffs or agglomerates. Thin-section examination of a hornblende-andesite lava collected by C. M. Bell from one of the localities (KG.1564) reveals an extremely altered nature. Euhedral to subhedral phenocrysts (up to 0.8 mm) of andesine with common zoning and widespread sericitization, hornblende, showing alteration to calcite and chlorite, together with isolated anhedral crystals and aggregates of magnetite occur in a fine-grained matrix of secondary minerals including epidote, calcite, chlorite, sericite, quartz and iron ore.

SEDIMENTARY ROCKS OF THE LEMAY FORMATION

Sediments of the LeMay Formation occur at several localities bordering the Rouen Mountains: on the ridges running into the Roberts Ice Piedmont and the lower slopes of Mount Calais in the north-east, in the south bordering Tufts Pass (Fig. 10), and on isolated ridges and faces in the west and north-west adjoining Russian Gap and Nichols Snowfield. Stoping by granite magmas in the south and granodioritic magmas in the north-east has produced coarse intrusion breccias (Fig. 6a and b).

Contact metamorphism (albite-epidote-hornfels facies) has affected all the sediments adjacent to the batholith and evidence of previous regional metamorphism is seen in the schistose nature of many of the exposures and in the formation of slates (KG.2040.1) on the

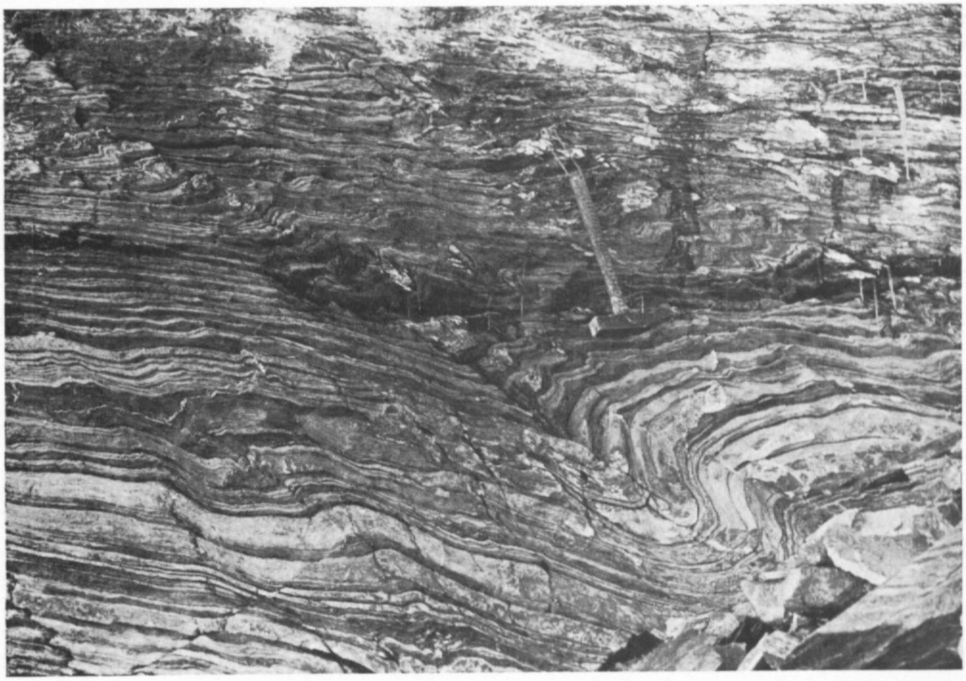


Fig. 10. Overturned beds of the LeMay Formation on the south side of Tufts Pass. The hammer shaft is 35 cm long.

north side of Tufts Pass, where microcrystalline quartz and sericite with rare epidote, sphene, muscovite and haematite form alternating layers which commonly enclose quartz augen.

The only unmetamorphosed sediments were seen in the north-west Elgar Uplands, where arkosic arenites (KG.2044) affected by slight shearing contain detrital quartz, labradorite/andesine, potash feldspar, sphene, hornblende and iron ore with secondary calcite and chlorite in a matrix of microcrystalline quartz, chlorite and sericite.

Contact metamorphism of schistose sediments from the north-west Rouen Mountains comprising alternating thin (1–3 mm) bands of argillaceous and arenaceous material has resulted in deep green banded rocks (KG.2279.6) in which subhedral flakes of chlorite (pseudomorphing biotite) are randomly orientated within a highly contorted matrix of quartz, orthoclase, microperthite and heavily saussuritized plagioclase. Abundant secondary minerals include fibrous mats of antigorite and penninite, anhedral chlorite, epidote and sphene. In the west Rouen Mountains (KG.2272), argillaceous rocks have been thermally metamorphosed to greenish quartz-chlorite-schists; rare detrital crystals of quartz and oligoclase occur in a matrix of recrystallized quartz and thin bands of muscovite and chlorite with scattered grains of sphene, epidote and magnetite.

Deep purple-black rocks crop out on the highest central and northern parts of the summit plateau. These roof-pendant rocks exhibit distinct banding and areas of deep red-weathering but the volcanic or sedimentary nature of the rocks could not be confirmed as none of the exposures was accessible.

XENOLITHIC MATERIAL

As access was limited by topography to the peripheral areas of the Rouen Mountains and hence to the marginal parts of the batholith, the majority of the igneous rocks examined were found to contain xenolithic material. These enclaves were composed essentially of two lithologies: schistose fragments of the sedimentary LeMay Formation and mesotype rock of granodioritic composition.

Xenoliths of sedimentary origin are seen only within the granodiorite and quartz-feldspar-porphyry. Quartzose material has been recrystallized to vague, rounded finer-grained patches within the host rock, discernible by a greater and more evenly distributed concentration of mafic minerals. However, angular green to purple argillaceous inclusions show little alteration except for a narrow bleached contact. In the north-west Rouen Mountains, where originally schistose metasediment has been incorporated into the granodiorite, recrystallization of the granulose layers into material resembling the host rock has left the micaceous layers "floating" in an apparently uniform matrix (Fig. 11).

Angular inclusions and irregular patches of pale to mid grey granodioritic rock are contained within paler granite on the low ridges to the south of Tufts Pass. Similar mid grey rock is seen to intrude sediments of the LeMay Formation on a few cliff faces to the south of these ridges and is itself intruded by granite to form an intrusion breccia (Fig. 6b). North-eastward away from the contact the xenoliths become less frequent, smaller and rounded but retain their sharp outline. Similar small rounded xenoliths are commonly found within the granodiorite of the north-west Rouen Mountains.

These non-sedimentary xenoliths vary widely in texture and have an overall granodioritic composition. At station KG.2046, the enclaves contained in a very coarse-grained granite display large euhedral pink feldspars and smaller rounded plagioclase and quartz crystals in a groundmass of sericitized plagioclase, quartz and biotite. The pink feldspar phenocrysts often show mantles of white feldspar and all the twinned plagioclase of the matrix exhibits rims of untwinned albite. Throughout the exposure the phenocryst minerals are irregularly distributed, giving textures from porphyritic to coarse- and even-grained, and in specimen KG.2046.7

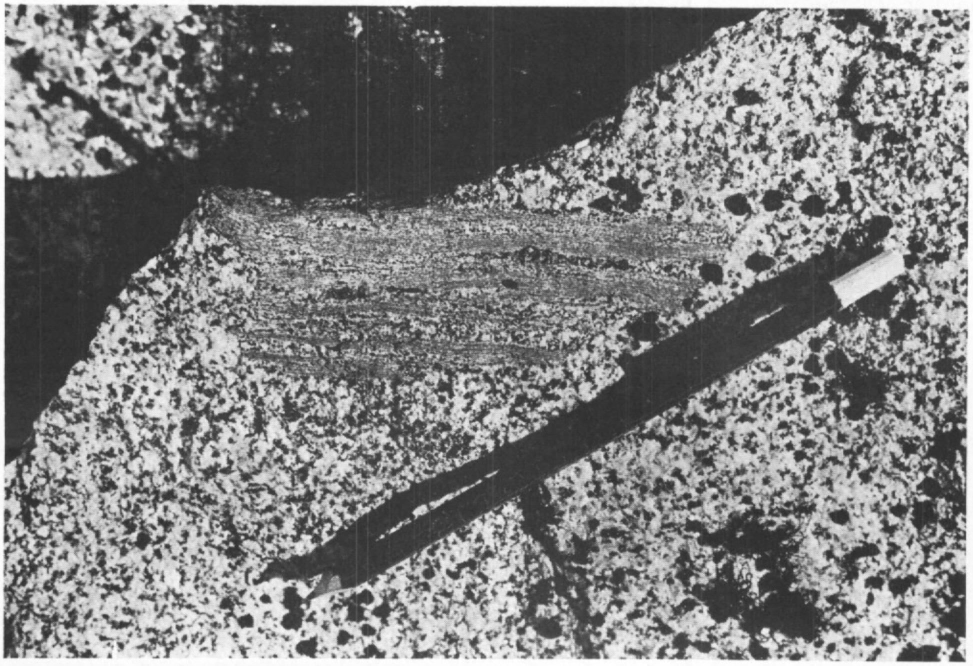


Fig. 11. A xenolith of banded metasedimentary rock within the granodiorite of the north-western Rouen Mountains. The arenaceous material has been more easily assimilated than the finer bands. The pencil is 15 cm long.

plagioclase and biotite are graphically intergrown with quartz.

On the south side of Tufts Pass, at station KG.2042, pink feldspar is a minor constituent of the xenoliths, which are generally finer-grained than elsewhere and contained in a medium-grained granite. Anhedral plagioclase, rare quartz aggregates and plates of orthoclase and microperthite are enclosed in a fine-grained matrix containing abundant ferromagnesian minerals. Hornblende (α = pale brown, β = green, γ = dark green and $\gamma : c = 12$–$17°$) occurs as corroded laths (up to 5 mm) but it is more common as smaller (1 mm) crystals, which together with biotite (α = straw, $\beta = \gamma$ = dark brown) form poikilitic inclusions in quartz and feldspar. Within the outcrop, a considerable range in composition is apparent due mainly to the variable amounts of quartz occurring as a phenocryst mineral and of hornblende in the groundmass.

Contact phenomena at this locality also differ. In specimen KG.2042.2 there is a sharp border between the fine- to medium-grained and even-grained xenolith and the host granite, and neither shows any obvious signs of alteration. However, a xenolith from another specimen (KG.2042.3) at the same locality displays a fine-grained dark green baked margin up to 3 cm in width with an irregular and sutured contact. This baked margin is composed of anhedral corroded biotite, hornblende, twinned andesine (An_{35-46}) with sericitized cores and mantled by untwinned feldspar, quartz and iron ore, with secondary chlorite and epidote. The coarser core has a similar composition but biotite is rare and almost completely replaced by chlorite, and the plagioclase shows mostly simple albite twinning with patchy albitization and no sericitization. Distributed throughout the enclave are numerous relict crystals and aggregates, some reaching 3 cm across, comprising zoned labradorite (An_{60}) with almost complete alteration to epidote, fractured augite, biotite, orthoclase, quartz, chlorite and sphene.

Approximately 2 km to the east, at station KG.2034, the xenolithic material shows yet another variation: it is medium-grained, non-porphyritic and has a higher colour index with abundant subhedral hornblende (up to 7 mm), iron ore and rare biotite set in a matrix of large plates of quartz, orthoclase, microperthite and labradorite (An_{56}).

Origin of xenolithic material

Several criteria are relevant to the nature of the non-sedimentary xenolithic material: an absence of relict sedimentary structures such as banding which is common in the adjacent LeMay Formation sediments, a granodioritic composition unlike that of the sedimentary rock, a finer grain-size than the enclosing granite and a concentration of xenoliths in the peripheral areas of the batholith rather than randomly throughout the intrusion. Grout (1937) considered the first two points indicative of an igneous rather than a sedimentary origin and the others he regarded as being typical of true xenolithic material derived from an independent and earlier formed igneous rock, as compared to cogenetic inclusions or segregations.

Table V gives modal analyses of two xenoliths together with the average compositions of the granite enclosing the xenoliths and the granodiorite from the Rouen Mountains batholith. Specimen KG.2034.3 is from the margin of a large xenolith, whilst specimen KG.2042.6 was collected from the centre of a nearby enclave. These two were chosen because of their even-grained texture and the absence of porphyroblasts.

The composition of the xenolithic core (as well as that of the marginal part) falls within the granodiorite field in Fig. 4. However, the granodiorite member of the Rouen Mountains batholith is not thought to be the source material as it is itself host to small xenoliths and differs in composition from the core material. It has approximately equal proportions of biotite and hornblende, and contains oligoclase/andesine, whereas the xenolith has labradorite and a similar percentage of ferromagnesian minerals but consisting almost entirely of hornblende. The tonalite (Table V, No. 5) is typical of the dominant plutonic rock in the Staccato Peaks area of southern Alexander Island, which has a variable content of biotite, hornblende and augite with labradorite (An_{50-65}) (Bell, 1973*b*).

TABLE V. MODAL ANALYSES COMPARING THE XENOLITHIC MATERIAL WITH INTRUSIVE ROCKS FROM THE ROUEN MOUNTAINS AND SOUTHERN ALEXANDER ISLAND

	1	2	3	4	5
		Xenolithic material			
	"Granite"	*Margin*	*Core*	*"Granodiorite"*	*Tonalite*
Quartz	38.9	33.8	20.1	21.3	19.8
Potash feldspar	45.6	17.5	14.8	10.0	8.5
Plagioclase	11.6	32.2	37.9	47.4	49.6
Hornblende	–	6.4	24.7	10.2	11.2
Biotite	3.1	6.7	0.5	10.2	7.1
Pyroxene	–	–	–	–	1.6
Iron ore	0.7	2.9	1.5	0.9	2.2
Accessories	0.1	0.5	0.5	–	–
Plagioclase composition	An_{17-23}	An_{57}	An_{56-60}	An_{15-43}	An_{50-65}

Minimum of 1 000 points counted per section.

1. Average of three analyses of granite from stations KG.2034 and 2042.
2. KG.2034.3 South side of Tufts Pass; margin of xenolith within granite.
3. KG.2042.6 South side of Tufts Pass; core of xenolith within granite.
4. Average of six analyses from the granodiorite phase of the Rouen Mountains batholith.
5. KG.1320.1 South Staccato Peaks; tonalite.

It is possible, therefore, that the xenoliths in the Rouen Mountains batholith could be genetically related to the tonalites and diorites in southern Alexander Island but, until a geochemical comparison can be made, no firm conclusions can be drawn.

REGIONAL SETTING

Renner and others (1982) have described a linear band of high magnetic anomalies running through western Palmer Land and continuing northward along the west coast of Graham Land (Fig. 5). They concluded that this anomaly represents a continuous batholithic feature of variable composition and depth intruded into continental basement and this is comparable to the Patagonian batholith of the southern Andes. This anomaly incorporates all the offshore islands of the west Antarctic Peninsula with the exception of Alexander Island and the South Shetland Islands, and in the south its western margin is sharply delineated by a submarine trench, reaching depths of 1 000 m, extending northward from George VI Sound. When traced farther north, this margin is approximately coincident with a series of bathymetric valleys from 600 to 800 m deep, which may represent relics of a now partly filled trench connecting George VI Sound and Bransfield Strait.

The regional setting of Alexander Island is thus very similar to that of the South Shetland Islands and geological similarities are also recognized. The plutonic rocks of the South Shetland Islands vary from gabbro to adamellite with tonalite predominating (personal communication from J. L. Smellie), and six K-Ar ages are available for these intrusions: 100 Ma for a quartz-diorite from Half Moon Island and 52 Ma for a granodiorite on King George Island (Grikurov and others, 1970), 40 Ma for a tonalite from Livingston Island

(Dalziel and others, 1973), 46 and 50 Ma for a granodiorite from King George Island (Watts, 1982) and 9.5 Ma for the Cornwallis Island granodiorite (Rex and Baker, 1973). The sedimentary Miers Bluff Formation of the South Shetland Islands has been compared structurally, palaeontologically and lithologically to the "Trinity Peninsula Series" of Graham Land, the Legoupil Formation of north-west Graham Land and the LeMay Formation of Alexander Island by various authors (Halpern, 1964; Miller, 1966; Dalziel, 1971; Thomson, 1975). Fossil plant leaves from the Elgar Uplands volcanic sequence of Alexander Island have been compared with those from the Upper Cretaceous–Lower Tertiary volcanic group of the South Shetland Islands (Thomson and Burn, 1977), and the Beethoven Peninsula volcanic rocks are regarded as members of a Cenozoic volcanic belt, which also includes the Upper Tertiary–Quaternary volcanic rocks of the South Shetland Islands.

The origin of the calc-alkali suite of rocks in the Antarctic Peninsula and the Patagonian batholith is attributed to an easterly dipping subduction zone situated to the west of the landmasses (Isacks and others, 1968) and the general younging in age of plutons westward across the Antarctic Peninsula is consistent with the progressive outward migration of a magmatic front associated with successive accretion of subducted material against the trench flank of an arc structure. Suárez (1976) has speculated that the LeMay Formation of Alexander Island represents a pre-Jurassic (?) trench assemblage and the presence of sheared pillow lavas, argillites, red cherts, serpentinized ultrabasic rocks and localized areas of glaucophane-schist facies metamorphism in central Alexander Island (Edwards, 1982) tends to support this hypothesis. The Miers Bluff Formation of the South Shetland Islands is also considered to be part of a trench assemblage (personal communication from J. L. Smellie) and pre-Jurassic glaucophane-schists have been described from Smith Island (Smellie and Clarkson, 1975).

The north–south belt of possible contemporaneous plutonic and volcanic rocks through central Alexander Island occurs within this pre-Jurassic (?) trench assemblage, which forms the "basement" for the fore-arc basin (arc–trench gap) of a migrating arc–trench system. These igneous rocks lie between 60 and 120 km west of the postulated Andean batholith and indicate that there has been a discrete jump in the magmatic front rather than a steady migration. Similar situations are recorded from the Indonesian arc and from the Kamchatka area of the north-west Pacific, where paired systems of magmatic fronts and trenches shifted jointly eastward in three discrete steps of about 125 km each (Avdeiko, 1971).

Proposed mechanisms for such "steppings" of magmatic fronts include changes in the dip of the subduction zone and the sweeping of intra-oceanic arcs or micro-continental scraps of sialic crust into subduction zones, where they lodge and cause the zone to "step" to the far side of the accreted material (Hamilton, 1969). Dickinson (1970) has suggested that a similar mechanism to the latter caused a jump of 100 km in the magmatic fronts of the Sierra Nevada batholith.

No mechanisms can yet be envisaged to explain the position of the belt of igneous rocks on Alexander Island but any put forward must take into account the consumption of the Aluk spreading centre beneath the Pacific margin of the West Antarctic plate, which Herron and Tucholke (1976) have shown occurred progressively from south to north during the late Palaeocene to Miocene.

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